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ABSTRACT

This reprint of a journal article focuses on the use of computers and other personal assistive devices by disabled persons. Topics covered include: a perspective on the use of advanced technology; distinction between technological appliances which provide benefits to the individual independent of the individual's skill level, versus tools which require development of special skills to gain full benefit of their use; skills or special knowledge needed for the effective delivery of rehabilitation technology; new roles for the service delivery team; sources of training in rehabilitation technology; and issues in qualification or certification of rehabilitation technology professionals. (JDD)

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SERVICE DELIVERY MECHANISMS IN REHABILITATION TECHNOLOGY

Vanderheiden, G.C.

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Service Delivery Mechanisms in Rehabilitation Technology

Gregg C. Vanderheiden

Key Words: certification • rehabilitation • technology

Rehabilitation technology is a rapidly advancing area involving professionals from multiple disciplines, including engineers, occupational and physical therapists, speech pathologists, computer programmers, and many others. This paper focuses on the use of computers and other personal assistive devices by disabled persons, but the concepts presented apply to all areas of personal rehabilitation technology. The topics covered include a perspective on the use of advanced technology, technological appliances versus tools, skills or special knowledge needed for the effective delivery of rehabilitation technology, new roles for the service delivery team, sources of training in rehabilitation technology, and issues in qualification or certification of rehabilitation technology professionals. The purpose of this paper is to put the use of advanced technology for rehabilitation in its proper perspective and to present ideas for consideration in building more effective service delivery mechanisms for these technologies.

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When the word *technology* is used today, it usually conjures up images of space-age gadgetry. However, it is important to acknowledge the existence and value of more fundamental devices or technologies as well as technologies employing electronic devices. Most of the advanced technological aids used in rehabilitation are simply adaptations of the more fundamental approaches or aids. Moreover, many of the problems faced by disabled persons are better solved through the use of fundamental technologies rather than through advanced aids. In fact, most advanced technologies require the presence of fundamental rehabilitation technologies to be effective or even usable. For example, in the case of a person with cerebral palsy, the use of advanced technologies (e.g., an electronic augmentative communication aid) will not be effective or useful until that person's basic seating and positioning needs are addressed through fundamental seating techniques and technologies.

The Use of Advanced Technology in Rehabilitation Today

Personal Versus Therapeutic Rehabilitation Technologies

The use of technology in rehabilitation is not new. Various devices have been used in *diagnostic, therapeutic,* and *personal assistive* roles from the beginning. Today, therapeutic technologies such as whirlpools and exercise devices are common rehabilitation tools, as are personal assistive rehabilitation devices such as splints, prostheses, wheelchairs, and reachers. Recent advances in technology have led to an explosion of rehabilitation technology, particularly in the area of personal assistive devices. Combined with the general technical advances in our society, these new and improved rehabilitation technologies can provide greater opportunities for rehabilitation and productive activity, particularly for persons with severe physical disabilities. However, the proper and effective use of these new technologies and opportunities requires new skills and adjustments in our service delivery programs. This paper focuses on the delivery of personal assistive rehabilitation technologies, and although the examples used are from the communication and computer access areas, most of the concepts behind them apply across the broader spectrum of personal assistive technologies.

Technology in Communication and Computer Access

Today's communication aids vary from large, fundamental, wooden communication boards to very small, portable electronic voice synthesizers. There are aids that can interpret erratic pointing motions and others that allow the selection of a word, phrase, or letter by

Figure 1
(a) A Specially Configured Lap Top Computer, (b) A Simple Key Guard Mounted Above A Keyboard, (c) Device Allowing Keyboarding Through Pointing at Keys, (d) Device Allowing Keyboarding Through Gazing at Keys, (e) Adaptive Firmware Card, (f) Special Switches and Interfaces for Use With Rehabilitation Technologies

means of very slight body movements (Vanderheiden & Lloyd, 1986).

Also available are small hand-held or lap top computers (see Figure 1a) that can be used as communication and writing systems for persons with the physical abilities to operate them. These systems may have built-in printers and voice output. For those who do not have quite enough control to use a standard keyboard, fundamental adaptations such as a key guard (see Figure 1b) can be placed over the keyboard to allow them to brace their hand and poke a finger down through the holes to type. Key guards also often have special latches that hold the shift key down to facilitate single-finger typing. Other adaptations include a miniature keyboard (for clients with good control but small range of motion) or a light pointer (for clients with limited upper limb control). A light pointer can be strapped on the wrist or mounted on a headpiece where it may be used to point a light beam at a special sensor panel (or even a computer screen drawing of a keyboard) to indicate choice of keys. When pointed to, the "keys" are treated by the computer as if they had been typed from the computer's regular keyboard (see Figure 1c). There are even keyboards that can be operated by simply looking at the "keys" (see Figure 1d), but these gaze keyboards currently require that the user hold his or her head very still (Vanderheiden, 1982; Bowes, 1984).

For persons who are not able to use any of these keyboard adaptations, there are interfaces (such as the Adaptive Firmware Card made for the Apple II family of computers; see Figure 1e) that provide complete control of the computer via a single switch. Some examples of specialized input switches used with these interfaces include brow movement switches, sip-and-puff switches, and lip, tongue, jaw, head, knee, touch, flex, squeeze, and blink or tip switches (see Figure 1f). These switches may be used with a variety of selection techniques (e.g., scanning or Morse code) to match individual user skills and requirements.

There are now close to 1,000 special adaptations and programs that allow persons with disabilities to use computers (Brandenburg & Vanderheiden, 1986). Most of these devices are not appropriate for all clients. In some cases, none of the existing hardware/software adaptations may be appropriate or effective for a particular person. The potential for computers and other advanced technologies to increase the capabilities of persons with disabilities is great, but the selection and/or development of aids along with the proper training and therapy programs to accompany them is very complicated.

The Misuse of Advanced Technology

Although it is obvious that advanced technology can help many people, it does not follow that the more

advanced or higher technology always provides a better solution. In some cases, electronic devices are inappropriately applied simply because nothing else has worked. In other cases, devices are selected on the basis of the mistaken belief that any technology is better than no technology, or that advanced technology is always better than fundamental devices or techniques.

It is very common that people are given communication aids they do not need simply because these aids are more "high-tech" than their current communication system. Consider, for example, the following true story:

> A therapist, after successfully interfacing a young girl with a switch, decided that an electronic scanning communication aid should be purchased for the girl. Because the therapist was unable to find the $1,000 purchase price for the aid, a local television station became involved and ran a special fund drive. A "thermometer" shown each night on the evening news kept track of donations, rising slowly over time until it hit the goal. The day the aid arrived, the TV station ran live coverage from the rehabilitation center. With all eyes trained on her, the young girl hit the switch and the lights began to move slowly down the display, row by row and then across item by item, until it finally reached a square with a prominent "Thank You" written on it. The light behind the "Thank You" began to flash, was greeted by applause from the audience and accompanied by the TV reporter extolling the wonders of modern technology. Then, with the camera still on her, the young girl took her finger off the switch and proceeded to point, rapidly and accurately, to each of the 100 squares on the communication screen.

It turned out that the young woman was perfectly able to point and already had a communication board with 280 squares, which she used on a daily basis. The wonders of modern technology had given her a switch and 8,000 transistors which, for $1,000, enabled her to communicate 10 times more slowly and with a vocabulary a third as large as the one she had with the communication board.

Once the aid was brought into the classroom, it became instantly apparent that it was in no way useful to her, but it was several weeks before she could get rid of the aid and return to her communication board because of all the publicity surrounding the aid's acquisition.

Even when high technology *is* warranted, fundamental technologies can be essential to achieving the full benefit. A poorly seated person may exhibit enough control to be able to operate a scanning aid, but not the faster direct-selection aids. Adding computerized selection techniques to the scanning may increase communication speed by 20% to 50%. But a proper seating system may enable the disabled person to move to direct selection, which would result in a five- to tenfold increase in communication speed. The maximum benefit would result from using both technologies, but the larger share of the benefit would derive from the fundamental technology.

Appliances Versus Tools

Many new techniques and devices are being developed and used to create new potentials and opportunities for disabled persons. It is important, however, to recognize that the solutions lie not in the technologies alone, but in the combination of technology, training, therapy, and other rehabilitation program components. To better understand the delivery and support systems required with the use of rehabilitation technologies, it is helpful to recognize that some technological aids fall into the category of appliances and others into the category of tools (Rodgers, 1985).

An *appliance* is a device or technology that provides benefits to the individual independent of the individual's skill level. In general, no skill is required to operate an appliance; the result is fixed, or the same for all users. A refrigerator is an example of an appliance. Once it is plugged in and turned on, a refrigerator runs by itself; no skill is required to operate it effectively. A videocassette recorder (VCR) is another example. Although one must learn how to run the VCR (i.e., push the correct buttons), how well the VCR performs is not a function of the skills of the person using it; the record button works the same for everyone. Appliances, of course, are fairly easy to use.

For *tools*, the quality of the output is a function of the user's skills. The results obtained from the use of tools can be extremely variable, depending on the user's abilities. A lathe is one example of a tool, but so is a frying pan. One person may be able to use a frying pan to produce exquisite dishes, whereas another person would only manage burnt french toast. Tools require more extensive training for effective use than do appliances.

In rehabilitation technology, there are both appliances and tools. Some examples of appliances used in rehabilitation are eyeglasses, hearing aids, and pacemakers. They must be properly selected and fitted to an individual, and the individual must be taught how to use them. However, these technologies operate nearly independently of the user.

On the other hand, rehabilitation tools such as prostheses, communication aids, and mobility aids require more than just careful selection/fitting and basic operating instructions. The user must develop special skills to gain the full benefit from these devices. This skill development requires therapy, modeling, practice, and learning a new way to do things. The learning process is made more difficult because the majority of people in the user's environment (i.e., the nondisabled people) use totally different tools to accomplish the same functions. Thus, it is not possible for persons with disabilities to master their special rehabilitation tools by simply watching the people

around them. For example, a disabled person may need to use a slow visual-graphic or voice output communication tool to communicate when the only models for effective communication available in the environment use the high-speed, oral speech with full intonation and unlimited vocabulary access that is characteristic of the speech of nondisabled persons.

Computers may fall into either the appliance or the tool category. A computer may be set up so that no skills are required to operate it (e.g., a demonstration program may be made to run again and again simply by turning the computer on). Rehabilitation programs can be written in such a way that they operate on the basis of simple commands and provide fixed, predictable results each time. A simple computer-based environmental control system would be an example of an appliance.

Computers may also be set for use as tools. For example, computers are often used as an alternative means of communication. At first glance, a computer equipped with voice output may be seen as an appliance (i.e., alternative vocal cords). However, even among people who can speak, the ability to effectively communicate varies greatly. Furthermore, these computer-based communication systems generally allow a person to communicate at only a fraction of the rate at which a nondisabled person can communicate. In fact, the rules for and the effectiveness of communicating change when the speed of communication is reduced to this extent. Thus, the provision of a computer-based communication would require (as would all communication systems) that the user learn not only how to physically operate the aid but also how to use it to communicate and interact effectively (at a very slow rate) in a predominantly vocal and fast-paced world.

The Effective Delivery of Rehabilitation Technology

The fact that many technological aids are tools, not appliances, has several implications for their delivery: (a) These aids cannot be placed effectively without appropriate therapy and training; (b) clinicians need training in specialized areas to effectively deliver rehabilitation technology; and (c) newer tools will require new training and skills for clinicians.

Appropriate Therapy and Training

The selection of a rehabilitation tool and its placement with the client is only the beginning of the delivery process. Yet, many times when a client is provided with a piece of technology, therapy is discontinued. Clients are commonly taken out of speech therapy, occupational therapy, or other therapies because an administrator, physician, or funding agency believes that the electronic aid solves the client's problem. The fact that the client needs training not only in *how to operate* the aid, but also in *how to effectively use* it to meet his or her needs is often forgotten, even by clinicians (Vanderheiden & Yoder, 1986).

Specialized Skills for Effective Delivery

In order for clinicians to develop the skills needed for the effective use of technological tools in their clients, they must themselves have these skills. In addition, the clinician must have special skills in the assessment, selection, and operation of the devices. The clinician needs to have

- an understanding of the various alternative devices for a given function (e.g. communication, mobility, etc.), along with their relative advantages and disadvantages
- skills at assessing the functionality of the different aids
- skills at assessing the abilities of the clients with regard to the different individual interface and control techniques (including sensory as well as physical requirements of the techniques)
- the ability to adapt and fit the various devices available
- skills and strategies for teaching the operation of the devices
- the ability to use the devices effectively in the real world
- the ability to teach others how to use the devices effectively in the real world

The last two items in the list are probably the least understood and appreciated, especially by administrators, funding agencies, and others not directly involved in the delivery of rehabilitation technology. It must be clearly understood that these technical aids may provide an alternative way for a disabled person to achieve some function, but that they are not an exact substitute for normal functioning. To achieve improved function with the help of the aids, the disabled person usually needs to use a modified approach, and efficiency and/or effectiveness are usually somewhat reduced. As a result, most of the rules about achieving function are so different from the rules used by a nondisabled person that the effective use of the aid cannot be learned by watching how nondisabled individuals commonly function.

Taking normal communication as an example, it can be seen that the rules change when different means of communication are used, as in the following story.

1. Two mechanics are working on a motor in a shop. One mechanic needs a screwdriver, so he looks up from his work and asks the other, "Pat, could you please hand me a screwdriver?"

2. The same two mechanics are working under water on a similar motor that afternoon. This time, they're wearing scuba diving equipment and must communicate using grease pencils and slates. The same mechanic needs a screwdriver. He picks up his grease pencil and slate, but what does he write? Does he slowly spell out "PAT, COULD YOU PLEASE HAND ME A SCREWDRIVER?" No, he just writes "SCREWDRIVER."

Why has this normally vocal person been reduced to using one-word utterances? Has the air in his diving tank decreased his intelligence? No. Being under water has just forced him to communicate in a fashion that has a much slower rate of speed. In these circumstances, the "normal" and "expected" way to communicate is in a much more compressed form than would be "normal" and "expected" if he were speaking aloud. In fact, if he *were* to slowly spell out the entire sentence using his grease pencil, it would be as unacceptable in these circumstances as speaking in one-word utterances is on dry land.

A barrier experiment by Chapanis, Ochsman, Parrish, and Weeks (1972) further illustrates that it is natural to use fewer words and fewer sentences to communicate when the communication rate is slower. In Chapanis et al.'s experiment, two subjects were placed on either side of a wall. Both subjects had partial information on a common problem. Neither could solve the problem individually, but by working together they could find a solution. Two groups of two subjects were used. In one group, the two subjects were allowed to speak; in the other group, the two subjects had to communicate by typing the questions and answers.

What the investigators discovered was that the subjects who communicated by typing used far fewer words than the subjects who talked. In one case, there wasn't a single properly formed (and spelled) sentence in the entire exchange between two typists. It generally took the typists twice as long to solve the puzzle because they were forced to use the slower typing mode for communication. However, the typists solved the puzzle using half as many words. Thus, like in the example of the scuba mechanics, the "normal" thing to do when a slower, graphic form of communication was to use shorter utterances, which often consisted only of fragments of words, phrases, and sentences.

The point here is twofold. First, these examples illustrate that persons using aids which result in communication that is slower or different from the communication of their vocal counterparts end up having to follow a different set of rules. To effectively teach the disabled persons to use different or slower aids, we must understand that the rules, as well as the strategies for using the aids, are different. We must also learn what these different rules for effective communication are. For example, most individuals who use communication boards are so slow that it is agonizing to communicate with them. Yet there are some people who are just as slow and yet make fascinating communicators. How do they do it? What different strategies do they use? Could we train other communication board users in these strategies?

The second point is that what is *normal* is not always the same in all circumstances. In the examples above, it was seen that *normal* (i.e., nondisabled) people do not communicate in long, full sentences when their speed is constrained. Yet young children on communication boards (who communicate even more slowly than this) are often required to communicate in full syntactical sentences because therapists insist that this is the "normal" thing to do (Blackstone, 1986). Clinicians need a much better understanding of the use, constraints, and rules (and strategies) for the effective use of these special aids if they are to be able to select and fit them and provide training in their use.

Training for New Tools

For many of the older, more established rehabilitation aids, the strategies for effective use have been identified, and these strategies have been passed on to clinicians through their training programs. Strategies for the effective use of tenodesis splints, mobile arm supports, artificial limbs, prosthetic hands and hooks, walking crutches, wheelchairs, and daily living aids are some examples.

As newer technologies are developed, however, several problems must be faced. First and foremost, it is important to remember that good strategies for many of the newer technologies have not been developed yet. In fact, there is a much greater need for developing effective strategies for the use of current aids than there is for developing the next generation of aids.

The second problem is the lack of good training programs dealing with the new rehabilitation technologies. Training programs must provide more than surveys of the latest technologies. They should also do the following:

- provide a genuine understanding of the different technological options in comparison with the more fundamental approaches
- develop assessment and interfacing skills
- teach effective use strategies
- teach methods for developing the skills needed by the clients

These clinical skill levels cannot be achieved through workshops alone. There is, therefore, a great need to identify what is necessary for the effective application of these technologies and to develop training strategies for clinicians and clients.

New Roles for the Service Delivery Team

In addressing these issues, one of the questions that arises is, Who should be applying rehabilitation technologies [i.e., which discipline(s) should be doing the evaluation, selection, fitting, and therapy]? Some have suggested that a new discipline is needed. I disagree. What is needed most are new skills within the existing disciplines. For the more advanced technologies, more technically oriented members may be needed in the teams. These may or may not be engineers, depending on the type of technologies involved. To see how the different disciplines might be involved, it is useful to look at the different functions or roles that may be needed for the effective delivery of rehabilitation technology.

Engineering—A Design Role

An engineer is someone who can create a technology. The skills of an engineer are most needed in situations where new technologies must be designed or existing technologies must be significantly changed (redesigned or reengineered). Since this is generally a very expensive process, aids are usually designed to be fairly flexible so that they can be adapted to meet the needs of the individual client without having to be redesigned or reengineered.

Some have suggested that rehabilitation technologies need to be applied by rehabilitation engineers. However, an engineer who designs a technology may or may not be qualified to apply that same technology. A very obvious case is that of the artificial hip. Although an artificial hip may be designed by an engineer, it takes a surgeon's skill to properly "install" it. Another example is an electronic communication aid. Although the engineer may design the aid, the selection, fitting, and application of that aid would require extensive knowledge and expertise in dealing with disabilities, impaired neuromotor systems, communication, and language development (and possibly retardation). In fact, the application of a communication aid usually requires very little, if any, classical engineering expertise, and a great deal of expertise in other areas.

The Role of the Technologist

Connecting various preengineered components does not require an engineering degree and can be done by anyone who is sufficently familiar with the technology to understand its assembly and use. The term *technologist* might be used to refer to a person who has sufficient technical training to be able to set up and configure, use, and adjust, or slightly modify technologies.

A *rehabilitation technologist* should have these skills *plus* an extensive knowledge of disabilities so that he or she can match the needs and constraints of various disabled persons with the appropriate technologies. The actual process of selecting the best technology, positioning the client properly, and training the client in the effective use of the technology requires both *technical* and *clinical* skills. Since it is usually not possible for an individual to be expert (technically and clinically) in all areas of rehabilitation technology, rehabilitation technologists would specialize.

A rehabilitation technologist would not need an engineering degree to have the necessary technical background to apply rehabilitation technologies effectively. However, having an engineer on the team does strengthen the team, especially where serious modifications to electrical or structural components are needed. An engineer with extensive clinical training and experience could also make an excellent rehabilitation technologist.

The Disciplines Involved

The delivery of technology is obviously not limited to any particular discipline. In looking at the broad range of areas, including computers access, wheelchair seating systems, power wheelchair control systems, communication and writing systems, automobile control, and functional electrical stimulation, it can be seen that many disciplines could and should be involved. Even within a single area, it is possible that the technology delivery process might be carried out by professionals from different disciplines. For example, training in occupational therapy would be an excellent base on which to build specialized training for wheelchair seating systems. However, an orthotist or prosthetist would have an excellent background for developing these specialized seating/positioning skills, as would several other professions. Thus, it can be seen that rehabilitation technologists will not be confined to specific disciplines but are likely to grow out of many disciplines through the addition of specialized training.

Occupational Therapists and Rehabilitation Technology

Occupational therapy would provide an excellent base for most any of the rehabilitation technology specialist areas. Occupational therapists have been using

and applying rehabilitation technology from the profession's beginning. For the most part, those technologies being applied by occupational therapists have been included in the core curricula. There are, however, many new rehabilitation technology areas that could be seen to fall neatly within the occupational therapist's purview, but for which they do not currently receive training. For example, providing access to computers for physically disabled persons could be a logical occupational therapy treatment goal. However, current training does not prepare an occupational therapist to assess or prescribe the different types of interface and access techniques for computers, even though the educational and clinical background of an occupational therapist provides an excellent basis for learning to apply this type of technology. Unfortunately, specialized training for most of the newer technologies must occur outside of the current already crowded core curriculum.

At the present time, it is not clear where therapists will be acquiring this specialized training and experience. It is probable that both will come from a number of sources. In the future, most therapists could be introduced to various technologies at least cursorily during their preservice training. In-service training could then augment this introduction, providing more in-depth knowledge about particular areas. Additional special extended training courses taught during the summer or at other specific times could provide clinicians with a chance to study particular technologies in greater depth. A practicum allowing therapists to participate side-by-side with other professionals in the application of a particular technology is one of the more powerful training methods today, especially regarding strategies for effective use. For the most part, these mechanisms have yet to be developed.

Qualification and Certification Issues

A major topic of debate at this time is the issue of qualification or certification. There are actually two parts to this issue: (a) Is there a need to qualify/certify rehabilitation technologists and (b) how and to what degree should they be qualified/certified?

Although there are no pat answers to these questions, it appears that the qualification and certification of rehabilitation technologists will be increasingly important to identify the professionals who have the necessary training and experience to make recommendations for particular types of personal rehabilitation technologies. Current professional training and certification procedures do not cover this specialized technological training and cannot be used to ensure adequate knowledge or experience in these technologies.

The fact that an individual has an occupational therapy degree, for example, does not mean that he or she is able to identify the best computer access or communication device for a client. However, as third-party payers begin paying for these (often expensive) technologies, they will want assurance that the professionals recommending and fitting the technologies are knowledgeable in the specific areas.

The question of who should develop and monitor the training and certification process is complicated by the interdisciplinary nature of the rehabilitation technology delivery process. For example, the selection, application, and training in the use of communication aids often requires expertise in

- seating and positioning
- communication and control interfacing
- speech therapy (to coordinate and maximize any residual oral speech)
- augmentative communciation/language skill development (vocabulary development, interaction skill development, augmentative communication strategies, etc.)

Because of the interdisciplinary nature of the rehabilitation technology application, the most desirable approach to certification may be through interdisciplinary, cooperative efforts or through cross-disciplinary agencies. In some cases, certification may be of individuals, whereas in other cases, the certification may be of a program or team.

Some areas of rehabilitation technology specialization might be

- seating and positioning systems
- communication and control systems
- sensory aids
- personal licensed vehicles
- functional electrical stimulation

Training and certification mechanisms are already in place in the fields of prosthetics (certified prosthetists), orthotics (certified orthotists, registered occupational therapists, licensed physical therapists, and others), and aids for daily living (registered occupational therapists, licensed physical therapists, and others).

Conclusion

Technology can provide many good tools. Properly selected and used, technology can greatly improve both the potential of and opportunities for persons with disabilities. As society incorporates more technology, it will become easier for people with disabilities to secure and hold jobs. Already, there are many positions that do not require the handling of paper,

books, or objects. As long as a person can effectively use a computer terminal, he or she can access all of the information that is needed to carry out these jobs. Telephone operators and copy editors in large newspapers are just two examples.

There is growing evidence that the proper application of rehabilitation technology has great potential for persons with disabilities, yet there is also evidence that the misapplication of these technologies can lead to a great waste of monetary and human resources. Another danger is that technology might become a goal rather than a tool in the rehabilitation process. It is up to the rehabilitation professions to work together to ensure the effective use of the technology available today as well as the technology that will be available tomorrow. The primary immediate needs are for more and better training programs in the rehabilitation technology specialty areas and for a mechanism to identify the professionals with the required knowledge and experience to effectively apply these new and emerging technologies.

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